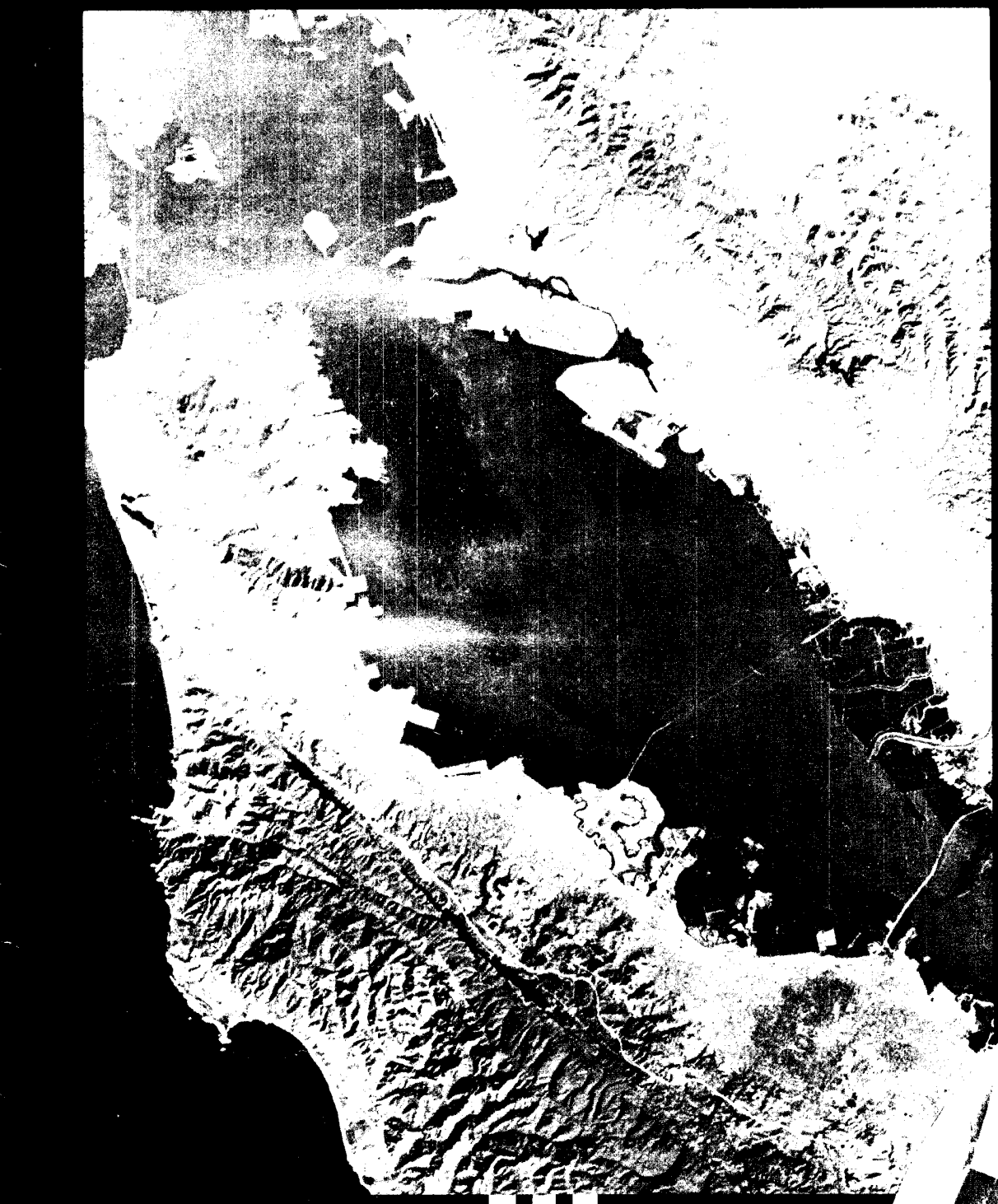
A New ERA in Landsat Earth Resources Applications

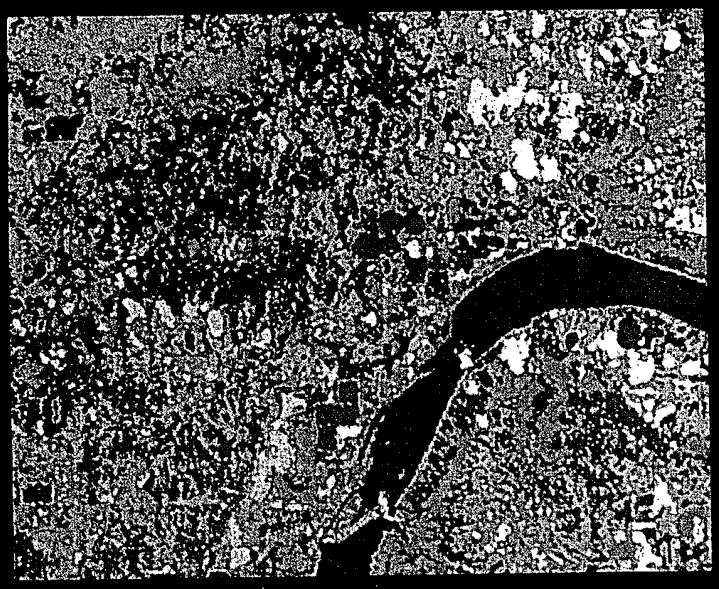
San Francisco Bay area TM image (six band transform color composite)



RESOURCE DISCRIMINATION

New Thematic Mapper Bands Provide Improved Capability to Discriminate Ground Cover

Information provided by EROS Data Center, Sioux Falls, South Dakota.

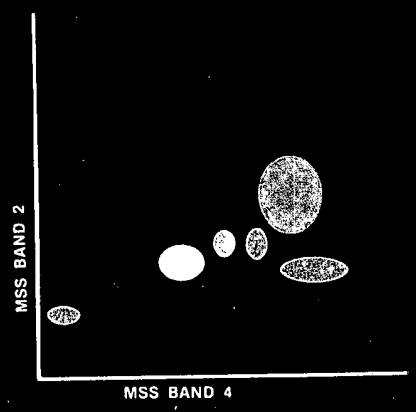


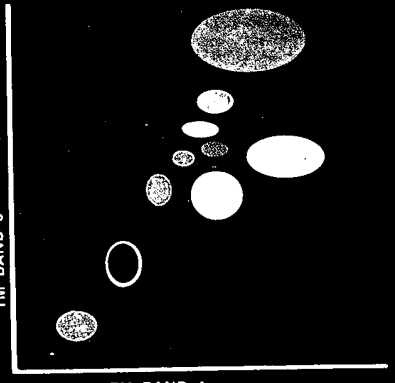
VEGETATION

The dynamic range of band 5 and a unique relationship between bands 4 and 5 make TM data important for mapping land cover. Analysis of MSS and TM data acquired over the Crow Creek Reservation in South Dakota yielded significant differences.

Only six resource classes were discernible in the MSS image on the left, as shown in the related cluster diagram. An approximate 2:1 improvement in the ability to extract resource classes is evident with the TM image and cluster diagram on the right.

The new capability can be used to monitor the status of an expanded set of natural vegetation classes.



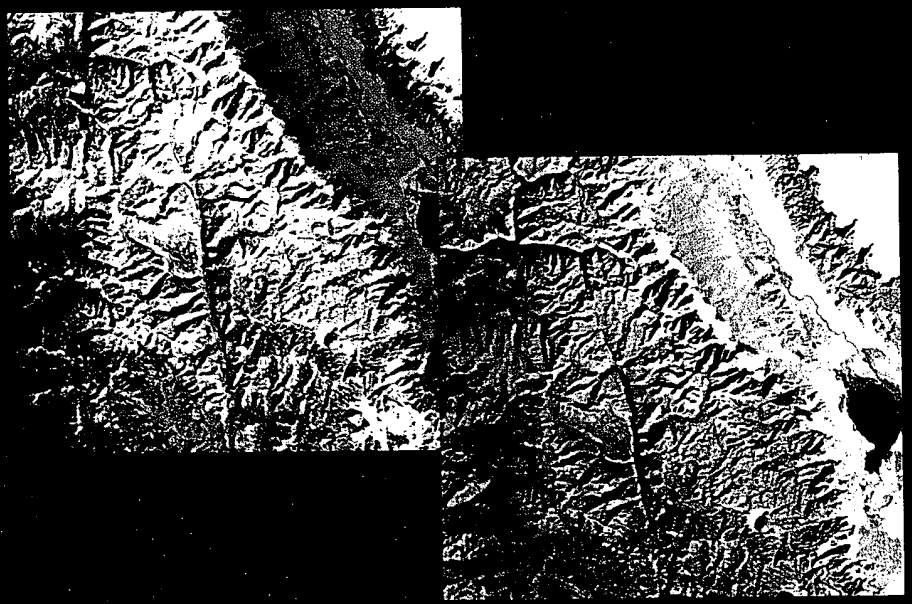


SNOW VS. CLOUD

In the western U.S., over 75% of the agricultural water supply comes from melting snow. Forecasts of spring and summer snowmelt are made from measurements of snow water equivalent at snow courses, and from snow-covered area measured from satellite data. Data from previous satellite sensors could not always be used to distinguish between snow and clouds.

The color composite images shown are made from TM bands 2, 3, 4 (left) and bands 2, 5, 7 (right). In the left-hand image, the clouds along the east side of the Sierra Nevada and over the White Mountains are similar in brightness and color to the snow. In the right-hand image, the snow (dark) and clouds (bright) are clearly distinguishable.

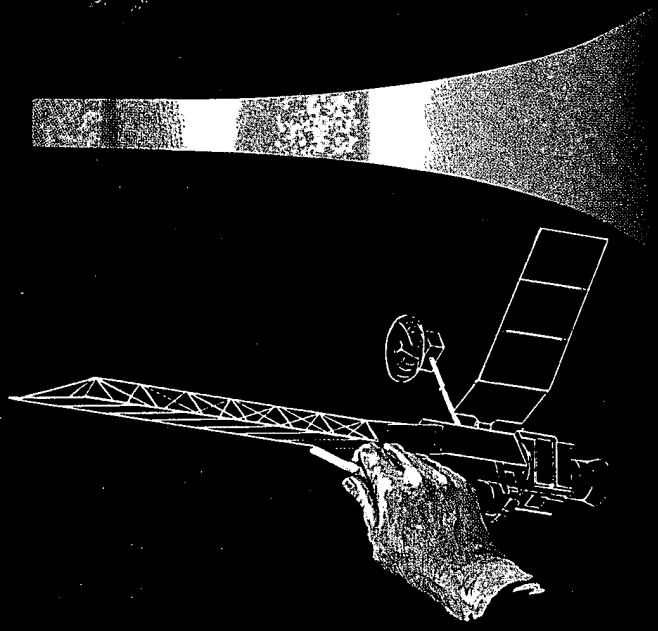
This enhanced capability provides a very useful tool for monitoring the snow-pack area and forecasting the snowmelt runoff.



Information provided by the University of California, Santa Barbara, California

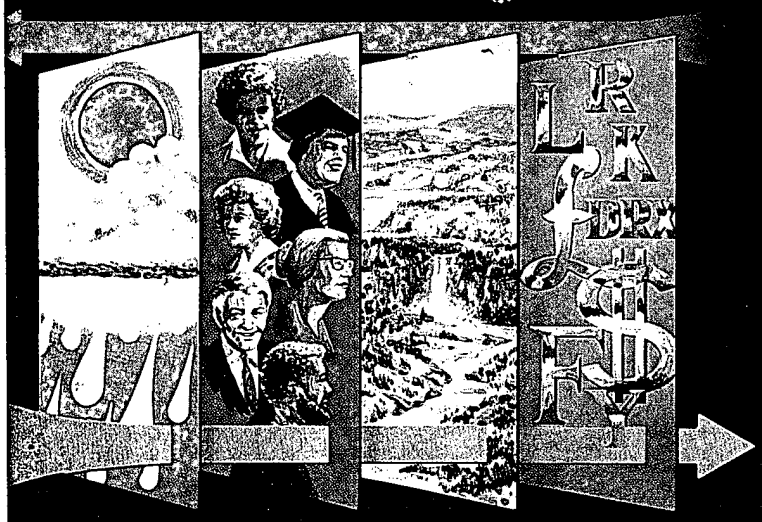
FUTURE DIRECTIONS

The new era in earth resources applications possible with the Landsat system and the Thematic Mapper sets the stage for a series of research challenges.



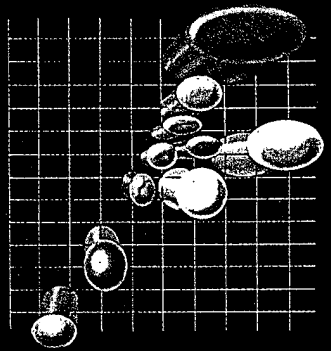
The new spectral bands in the reflective and thermal infrared need to be studied further to fully understand the physics of reflection and emission occurring in plant, soils, snow, water and the atmosphere. The optimum combinations of spectral bands must be evaluated to determine the potential for an enhanced resource assessment capability.

New solid-state and electrically-scanned sensor systems can provide higher spatial resolution in the 10-20 meter range. At the same time, the ability to more accurately and precisely observe emitted and reflected radiation in narrower intervals throughout much of the electromagnetic spectrum is achievable. Further, as the result of microwave and laser energy beamed from future satellite systems, the emitted and reflected radiation can be measured to determine the character and condition of surface materials.



Higher spatial resolution provides much more detail in images of the earth's surface which can be appreciated by visual interpretation but not adequately utilized by existing processing/extraction techniques. Computer technology and methods for combining large volumes of satellite data with other sources of information such as climatological, demographic, topographic and financial information need to be refined and enhanced. Information resulting from the processing of interactive data bases must be made readily and inexpensively available for resource planning and decision making.

There is significant promise for improved management of the earth's resources and understanding the magnitude and importance of processes occurring at or near the earth's surface. Learning how to examine and exploit data that have multiple independent components or dimensions will be a key step in developing the required advanced analytical tools. The engineering/scientific community must continue to work with the resource management and policy-making communities to exploit this technology and achieve positive benefits for mankind.

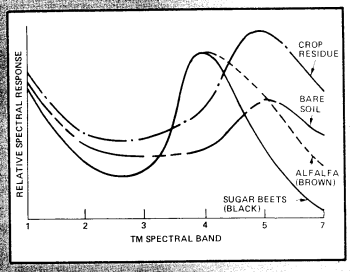


Information provided by NASA Goddard Space Flight Center, Greenbelt, Maryland

AGRICULTURE

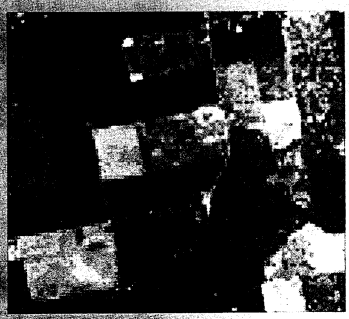
Improved Crop Identification Enables Enhanced Global Forecasting

Different crops appear the same on satellite imagery during certain times of the growing season. Identification requires several different acquisitions. TM band 5 data allows discrimination of many previously inseparable cover types with a single satellite data acquisition. TM images of the San Joaquin Valley, California, illustrate this feature.



The image on the left combines TM bands 2, 3 and 4. Fields of bare soil and crop residue are the light tones. Healthy vegetation is shown in various shades of red; note the "L-shaped" group of fields in the top central portion. All fields reflect similar amounts of radiation in bands 2, 3 and 4 and appear identical. In the right hand image, combining TM bands 2, 3 and 5, a striking difference is evident due to the band 5 responsiveness to the plant canopy moisture content. The darker fields (black) are sugar beets with a higher leaf water content than the lighter (brown) fields of alfalfa located between them. This difference is also demonstrated by the brightness histogram on the left.

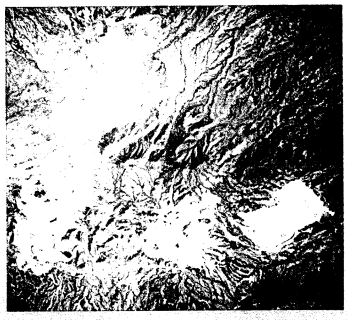
New TM band 5 and higher spatial resolution have significantly improved the ability to discriminate ground cover types, enhancing global resource survey/ forecasting.



Information provided by University of California, Berkeley, California

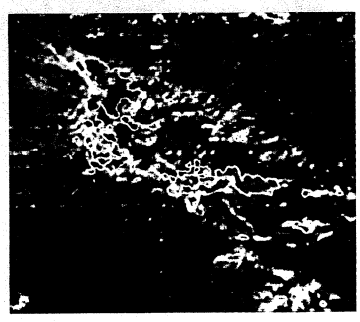
GEOLOGY

New TM Bands 5 and 7 Make Major Contributions to Geological Exploration



Silver Bell, Arizona, is a copper mining district in which certain clay minerals diagnostic of subsurface mineralization are exposed at the earth's surface. These clay minerals are not readily apparent in standard aerial photographs (upper left) and they are difficult to identify in the field.

These minerals possess distinctive reflectance characteristics that can be detected in TM imagery. Surface concentrations of these clays appear as a greenish linear trend in the image on the upper right using TM bands 1, 5 and 7. The clay alteration zone associated with the Silver Bell deposit starts from the mine tailing ponds at the right of the scene, extends through two open pit copper mines (shown in shades of purple and blue), and then trends abruptly upward.



The final image (lower right) depicts those areas containing significant concentrations of the clays in red. This image demonstrates the utility of TM data for detecting surface alteration zones, particularly in remote and unexplored regions.

Information provided by U.S. Geological Survey, Flagstaff, Arizona.

NASA NOAA

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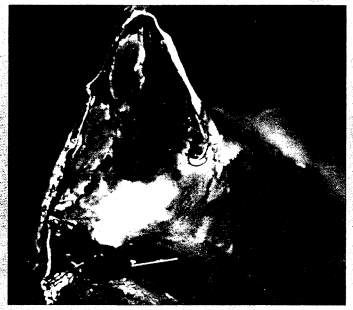
APPLICATIONS

BATHYMETRY

Improved Coastal Mapping Using New TM Band 1



A natural color rendition of Bimini Island using TM bands 1, 2 and 3 is shown at the upper left. A bottom cover map at the upper right shows the density of benthic vegetation. The darker tones represent more heavily vegetated areas. Bottom cover density is developed by a ratio of TM bands 1 and 2, using estimated water attenuation coefficients. In effect, the image does not vary with water depth, showing the bottom cover density.

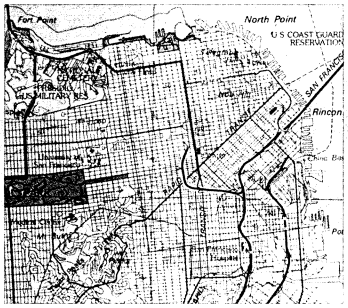
A water depth map at the lower left is shown in varying shades of gray: dark = deep, light = shallow. Using known depths measured at several points, a two band (TM bands 1 and 2) regression was developed to compute water depths over the entire image.

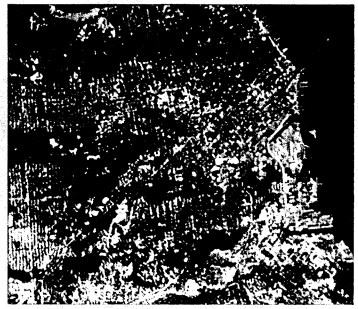
This capability will be very helpful in updating older marine charts and providing new coastal area maps.

Information provided by NASA Goddard Space Flight Center, Greenbelt, Maryland

CARTOGRAPHY

Upgraded and Improved Map Making Capability Using Landsat Data





Improved Landsat spacecraft capability and greater spatial resolution allow map makers to match conventional mapping accuracies using Landsat TM data. The U.S. Geological Survey has demonstrated the use of TM data for making maps to 1:100,000 scale standards. Thus, Landsat data can be used as a cartographic reference for areas where no maps exist or upgrading existing maps.

The example shows a line map (upper left) and TM image (upper right) of the San Francisco waterfront area. The map was published in 1977. The TM data was acquired in December, 1982. Note the differences between the map and the image. For example, there are docks shown on the map that do not appear on the Landsat image. In fact, the docks burned down several years after the map was generated. The image at the bottom right represents a current Landsat upgraded map of the area. The availability of Landsat data on a recurring basis will facilitate the upgrading of existing area maps.

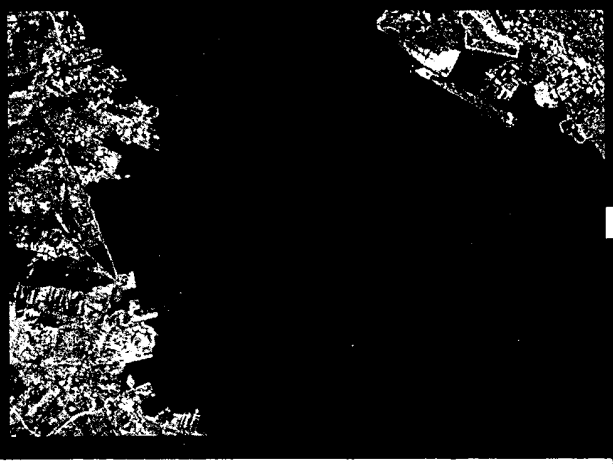
Information provided by IBM, Palo Alto, California.

SYSTEM APPLICATIONS

The new generation Landsat system provides improved spatial (to less than 30 meters), multispectral (0.45 μ meters to 12.5 μ meters) digital and photographic data of the earth's resources. The data available with the seven band Thematic Mapper (TM), relative to Multispectral Scanner (MSS) data, allows improved enhancement and discrimination of resource categories including water, land cover and geology.

Multiple users can be served by individual Landsat images. Temporal resource assessments are made possible by a 16-day repeat coverage cycle, providing multiple views of the same scene throughout the year.

WATER - Turbidity patterns and sediment concentrations are readily measurable from TM data, with turbidity information significantly enhanced by the use of new TM band 1. Also, data from band 1 in various combinations with bands 2 and 3 can assist in the detection of submerged aquatic vegetation and other water features. Surface thermal patterns can be extracted using the TM thermal band 6, while accurate measurement of water-land boundaries and the area of small water bodies is facilitated using TM bands 4, 5 or 7 and the inherent high spatial resolution.



LAND COVER - More accurate and detailed land cover mapping is achievable through the improved multispectral and spatial capability of the TM. A three band classification, shown on the right, demonstrates the capability to classify small land features. Note the variety of pond colors and the diversity of color codes in the surrounding land, including the residential and urban areas on both sides of the lower bay, signifying the broad range of distinguishable land cover categories.

GEOLOGY - Geologic structures and drainage patterns can be easily recognized and accurately plotted due to the increased TM spatial resolution, adding to the tectonic detail of an area. The San Andreas and other faults trend northwestward across the scene. The Santa Cruz mountains are highly faulted, composed of Mesozoic granitic rocks and Jurassic-Cretaceous marine sediments. Surface mineralization and vegetation type or condition, extractable from the TM data with new bands 5 and 7, are important keys to rock unit mapping. The result is better and more complete maps for mineral and petroleum exploration.

Information provided by GE DIAL Facility, Lanham, Maryland.

General Electric consulted with several specialists at NASA and NOAA in the preparation of this brochure. Their advice and contributions are greatly appreciated.

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